DOCUMENT RESUME

ED 225 338 EC 150 697

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TITLE Problem Solving Strategies of Learning Disabled and Nondisabled Learners on a Multiple Discrimination Task.
INSTITUTION West Virginia Univ., Morgantown. Coll. of Human Resources and Education.
PUB DATE Apr 81
NOTE 20p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Development; Elementary Education; *Learning Disabilities; *Problem Solving

ABSTRACT

The problem solving strategies of 17 learning disabled (LD) and 17 non LD boys at the upper elementary level were compared across four multiple discrimination tasks listing a split plot analysis of variance design. Ss were randomly assigned to one of two conditions in which feedback stimuli were either removed or maintained. Ss' performances on four ordered tasks were measured in terms of number of trials, time per trial, errors, and strategy score. LD Ss required significantly more time per trial across tasks and, in general, used less efficient problem solving strategies than non LD Ss. Results suggested that LD Ss do not acquire problem solving skills by the expected chronological age, and may therfore need special training programs to develop them. (Author)

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ED225338

Problem Solving Strategies of Learning Disabled and Nondisabled Learners on a Multiple Discrimination Task

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April 1981

Running head: Problem Solving Strategies

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Abstract

The problem solving strategies of learning disabled and nondisabled boys at the upper elementary school level were compared across four multiple discrimination tasks using a split plot analysis of variance design. Seventeen disabled students and seventeen nondisabled students, matched for age, were randomly assigned to one of two conditions in which feedback stimuli were either removed or maintained. Their performances on four ordered tasks were measured in terms of number of trials, time per trial, errors, and strategy score. The learning disabled group required significantly more time per trial across tasks and, in general, used less efficient problem solving strategies than the nondisabled group. These results suggest that disabled students do not acquire problem solving skills by the expected chronological age, and may therefore need special training programs to develop them.

Problem Solving Strategies of Learning Disabled and Nondisabled Learners on a Multiple Discrimination Task

The rapid growth of special education programs for students with learning disabilities has generated renewed interest in pinpointing the characteristics of such students which create learning difficulties. The failure of traditional training exercises to eliminate the deficiencies of disabled students has led to rejection of perceptual theories and stimulated a search for a more satisfactory explanation of the underlying processes involved in the phenomenon of specific learning disabilities. As a result, researchers have begun to examine the cognitive as well as the perceptual problems of learning disabled students.

Educators have recently become concerned about assessing the ability of learning disabled students to acquire the higher level cognitive skills required for problem solving. Because disabled students possess intellectual abilities within the normal range, they should be able to process information at or above grade level, and in a manner similar to that of average learners (Alley & Deshler, 1978), but their specific disabilities appear to interfere with their performance efficiency. Characteristics of disabled students which might be expected to impair problem solving include impulsivity, or the inability to delay responding until all alternatives have been evaluated (Dykman, Ackerman, Clements & Peters, 1971; Keough, 1971; Keough & Donlon 1972; Tarver & Hallahan, 1974); field dependency, ie, the tendency to respond unselectively or to fail to ignore irrelevant stimuli (Atkinson & Seunath, 1973; Parker et al, 1975); and deficient memory (Lerner, 1976; McSpadden & Strain, 1977; Wallace & McLaughlin, 1979).

Preliminary studies comparing the performance of disabled and nondisabled learners indicate that disabled students require more trials to reach criterion

in discrimination tasks (Wirtenberg & Faw, 1975) and tend to be misled by irrelevant information, to exhibit random behavior or impulsive guessing, and to recall nonessential information (Havertape, 1976). But the extent of these disorders of problem solving and the conditions under which they occur require further clarification. Research analyzing the performance of learning disabled students in terms of such variables as amount of learning, speed of acquisition, information processing strategies, and response patterns is needed before remedial strategies appropriate to the needs of these students can be developed.

The problem solving skills of nondisabled learners of all ages have been well documented, using discrimination tasks in which subjects are required to indicate which of two or more alternative stimuli represents a positive instance of some concept or rule. Results of these studies have led to an explanation of the development of problem solving behavior by hypothesis theory, as proposed by Levine (1963; 1966; 1975). Such theory assumes that the learner samples potential hypotheses leading to problem solution from some total set of hypotheses inherent in the conditions of the specific problem. Strategy selection may take the form of testing all possible hypotheses simultaneously, testing one hypothesis at a time, or testing random samples of hypotheses successively (Restle, 1962). Overt responses are presumed to reflect the pattern of hypotheses being tested in the process of attempting to find the correct solution. Investigations of the problem solving behavior of children have identified ineffective approaches (stereotypes) and effective approaches (strategies); strategies permit the subject to systematically eliminate hypotheses until the solution is attained (Eimas, 1969; 1970a; 1970b; Gholson, Levine & Phillips, 1972; Goodwin, 1977; Ingalls & Dickerson, 1969; Phillips, 1974).

Even young children employ strategies, but the ability to use more efficient strategies (ie, those which eliminate more information per trial)

increases with age and depends to some extent on problem conditions such as number and complexity of stimuli and feedback conditions (Cantor & Spiker, 1978; Gholson, Phillips & Levine, 1973; Kemler, 1979). The use of improved strategies with advancing age appears to result from increased perceptual abilities, longer memory span, and the acquisition of more numerous and complex rules for organizing sensory input into concepts (Mussen, Conger & Kagan, 1975).

Travers (1972) has suggested that the strategies used by a subject to solve problems is apparent in the pattern of responses to solution; subjects differ in the manner in which they attack problems in terms of extent of reflection (estimated by time per trial), efficiency (measured by trials to completion and error rate), and style of problem solving (reflected in response strategy). Characteristics of learning disabled students such as short memory span, disordered selective attention, and impulsive responding, which are frequently attributed to a maturational lag in the development of cognitive skills, would be expected to result in problem solving ability inferior to that of nondisabled students of the same chronological age. The present study was designed to assess the problem solving performance and use of hypothesis testing strategies by disabled and nondisabled learners on four tasks requiring multiple stimulus discriminations, under two conditions which permitted either temporary or continued access to corrective feedback in order to assess the influence of differential memory abilities.

Method

Subjects

Subjects were selected from children enrolled in the fourth, fifth, and sixth grades in public school classes in the Monongalia County and Marion County school systems in central West Virginia and for whom written parental consent was obtained. [1] A test for colorblindness was administered to screen for eligibility to participate. The nondisabled subjects were boys with IQ scores in the normal range and no indication of colorblindness, who were approximately 11 years of age ($\bar{x}$ = 131.8 months, range 110 to 149 months) and enrolled in regular elementary classrooms. The disabled subjects were boys with similar IQ scores, no indication of colorblindness, and of equivalent age ($\bar{x}$ = 126.0 months, range 114 to 146 months), who were identified as learning disabled by qualified personnel according to guidelines issued by the State of West Virginia [2] and placed in appropriate special education programs. A total of seventeen nondisabled learners and seventeen disabled learners were randomly assigned to one of two feedback conditions.

Design and Materials

The 2 x 2 x 4 mixed design included one within subjects factor (tasks) and two between subjects factors. The between subjects factors were (a) group (disabled versus nondisabled subjects), and (b) feedback condition (temporary versus continued access to feedback stimuli).

Subjects in the first feedback condition were permitted to have access to all previous stimuli selections and all confirming/disconfirming feedback stimuli; those in the second feedback condition were permitted only temporary access to selection and feedback stimuli, since all previous stimuli were removed approximately 60 seconds after each trial.

Tasks involved four different problems from the commercial board game Mastermind, which consisted of a decoding board with holes and a shield to hide the code, pegs of eight different colors for decoding, and black and white pegs for providing feedback. They were arranged according to dimensional variability and presumed level of difficulty, based on conclusions from a study by Zelniker, Openheimer & Renan (1975). Task 1 used a pattern of two colors grouped together, such as: blue, blue, green, green; Task 2 used a pattern of two colors in alternation, such as: yellow, red, yellow, red; Task 3 used a pattern with a single color repetition, such as: red, white, blue, red, and task 4 used a nonrepetitive pattern including a blank hole, such as: orange, brown, blank, yellow.

Procedure

All subjects were tested individually in a separate room within the school building. The examiner asked the subjects to try to duplicate the code (pattern of pegs preselected by the examiner) by using various combinations of colored pegs and/or empty holes, and informed them that the black and white pegs would be used to confirm or disconfirm their guesses after each trial.

Two demonstration games using a different color in each hole were played with each subject to familiarize him/her with the task and the feedback procedure. Feedback for each trial was provided by the examiner, who placed black pegs in the feedback grid in positions corresponding to those in which the subject had selected the correct color, placed white pegs in positions corresponding to those in which the subject had identified a correct color in an incorrect position, and placed no peg in positions corresponding to those in which the subject had identified a color incorrect for any position within the code.

During the experimental tasks, the examiner recorded subject responses on a separate sheet according to color and position, and marked the time to

completion for each task (solution of the problem). Response protocols were later scored for number of trials to completion, errors, and strategy score. Errors of inclusion were defined as use of a color previously disconfirmed in the same position or use of a color previously disconfirmed for any position; errors of exclusion were defined as failure to continue to use a color previously confirmed for a given position.

All subjects were assigned a strategy score for each task, on the basis of the pattern of responses used to solve the problem. A score of four was assigned to subjects who tried all eight colors and the blank within the first three trials without repetition of confirmed colors; a score of three was assigned to subjects who tried all colors but not the blank within the first three trials; a score of two was assigned to subjects who tried all eight colors as soon as possible, allowing for repetition of confirmed colors; and a score of one was assigned to all other subjects, whose performance suggested no use of a consistent strategy. [3]Scores of three of four reflect the higher levels of focussing, a problem solving strategy which produces solutions by eliminating information in conjunction with progressive narrowing of hypotheses.

Errors were classified either as errors of exclusion (failure to include a confirmed color) or errors of inclusion (selection of a color disconfirmed by feedback for a previous trial). Inclusive errors were further described as occurring in the same position (i.e., selection of a color disconfirmed by a white feedback peg identifying a correct color in an incorrect position) or in different positions (i.e., selection of a color disconfirmed by no feedback peg identifying a color incorrect for any position).

Results

A separate mixed analysis of variance involving group x feedback condition x task was performed for each of four dependent variables: time per trial, trials to completion, total errors, and strategy score.

The analysis for time per trial produced a significant feedback condition x task interaction ($F = 4.15$ $df = 3$, $p < .01$); further analysis of the simple main effects revealed that subjects in the continuous access condition took more time on the first task than on other tasks and more time in general across tasks than subjects in the temporary access condition ($F = 5.49$, $df = 3$, $p < .003$). The most important finding, however, was the significant main effect for group ($F = 12.75$ $df = 1$, $p < .001$) with the learning disabled students requiring more time per trial ($\bar{x} = 21.05$ seconds) than the nondisabled students ($\bar{x} = 14.39$ seconds); all other main effects and interactions were nonsignificant ($p > .05$).

No significant differences were found for any of the independent variables in the analysis performed for trials to completion ($p > .05$).

The results of the analysis for total errors showed only a significant main effect for task ($F = 3.35$, $f = 3$, $p < .02$), with further analysis using the Duncan multiple range test attributing the difference to more errors during the initial task (See Table 1). No other significant effects or interactions were found ($p > .05$).

The analyses for strategy score found no interactions ($p > .05$) but three significant main effects: task ($F = 5.52$, $df = 3$, $p < .002$), feedback condition ($F = 5.15$, $df = 1$, $p < .03$), and group ($F = 6.68$, $df = 1$, $p < .01$). Additional analyses indicated that the highest strategy scores were elicited by the first task (See Table 1), and by the continuous access condition ($\bar{x} = 2.19$) rather than the temporary access condition ($\bar{x} = 1.62$), while nondisabled students used higher level strategies ($\bar{x} = 2.17$) than disabled students ($\bar{x} = 1.58$).

An analysis of errors by type found no significant differences for errors of exclusion ($p > .05$) but a main effect for task for errors of inclusion in

the same position (F = 3.42, df = 3, $p < .02$) and in different positions (F = 3.62, df = 3, $p < .02$). The Duncan's analysis subsequently showed that the initial task elicited more errors in different positions ($\bar{x}$ = 2.21) while the second task elicited fewer errors in the same position ($\bar{x}$ = 0.43) than the other tasks. A summary of all means is contained in Table 1.

Insert Table 1 About Here

Discussion

The results of this investigation clearly showed that learning disabled students did not demonstrate problem solving abilities similar to that of non-disabled students of the same age. They not only used minimally efficient hypothesis testing strategies little better than random guessing, but also took more trials to reach solution. This suggests that strategy selection and use by disabled students cannot be expected to follow the normal developmental pattern, and direct training efforts may be necessary if such students are to successfully apply cognitive strategies in problem situations.

Disabled students required significantly more time per trial across tasks (See Table 1), which probably reflected the observed tendency of many subjects to experience difficulty in maintaining attention to task stimuli. Both impulsivity as a style of responding (frequently identified as a characteristic of disabled learners) and selective attention deficits are implicated in the failure of the disabled subjects to use systematic strategies.

The nondisabled group used simple forms of hypothesis testing ($\bar{x}$ = 2.17) by varying color selection in initial trials until the correct colors were identified, then varying position until the correct code combination was obtained. The disabled group, on the other hand (See Table 1) were more likely to use random strategies ($\bar{x}$ = 1.58) in which color and position combinations

were tested in haphazard fashion. The fact that groups did not differ on trials to completion or errors suggests that lower strategy levels may not be much more efficient than guessing in solving simple multiple discrimination problems of the type used in the experimental tasks.

The significant main effect for task on the analysis of errors probably reflects practice or learning-to-learn effects, which are anticipated in repeated measures designs, where successive exposures to similar tasks generally produce gradually improving performance. The finding that the initial task elicited the highest strategy scores, however, occurred in contradiction to this predicted practice effect. The results of the analysis of errors by type, which found that subjects tended to repeat disconfirmed colors in the same position on the second task may reflect some unknown effect of the sequence of stimulus colors for each task.

The results also indicated that subjects used higher focusing levels in the first feedback condition where continued access to feedback was provided; this may represent an effect of the lower memory demands when corrective stimuli were continually available for comparison. The condition by task interaction for the dependent variable time per trial (where subjects with continued access took more time on the first task) is probably best interpreted in terms of the amount of time which elapsed while subjects were checking the feedback prior to stimuli selection during their initial exposure to the task presentation. In the limited access condition, subjects had to select strategies more quickly, since only temporary exposure to feedback stimulis was permitted.

A potential problem in interpretation is related to the fact that disabled subjects required considerable prompting by the examiners to keep on task. This suggests the possibility that attention differences, rather than

cognitive skill deficits may explain the observed differences between groups. Current research and theory deemphasize the role of attending deficits in depressing the performance of learning disabled students, because their occurrence has not been reliably demonstrated. Further, problems in attending are equally attributable to the frustration and boredom which may accompany a task that is beyond the present skill level of the learner. An additional limitation of the study was the sequencing of the tasks according to presumed level of difficulty, which was not confirmed by the results. In view of this, the design would have been improved by randomization of the order of presentation to avoid order effects attributable to the specific nature of the tasks themselves.

The findings of this study have some important implications for researchers in the area of human problem solving and its development and for educators concerned with curriculum and teaching strategies for learning disabled individuals. The failure of disabled students to use even minimally efficient strategies similar to those of their nondisabled peers, suggests that specific learning deficits may impede the normal developmental growth of cognitive abilities. Further research is needed to explore component areas (e.g., attention, memory, encoding) which may contribute to the acquisition of higher level cognitive skills such as problem solving. Studies varying the amount and nature of extraneous stimuli and/or the number and type of relevant and irrelevant task dimensions are indicated to clarify the effects of distractibility and selective attention.

The poorer performance of learning disabled students on these simple problem solving tasks indicates that the development of cognitive strategies for learning cannot be left to chance; specific instruction and possibly remedial activities will be needed if disabled students are to become efficient learners. Special education personnel should direct attention to applying

research findings to the design of improved training techniques and remedial materials to facilitate the acquistion and use of both component cognitive skills and general organizational strategies for problem solving by learning disabled students.

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Footnotes

1. Appreciation for cooperation is expressed to Mr. Jack Dulaney, Dr. Clarence Harvey, Jr. and the staff of Monongalia County Schools, and to Mr. T. J. Pearse, Mr. Dennis Edge, Ms. Sarah Eddy and the staff of Marion County Schools for their assistance with this research.

2. Eligibility criteria for programs for specific learning disabilities are published by the West Virginia Department of Education in Standards for the Education of Exceptional Children, Charleston, West Virginia: West Virginia Board of Education, August, 1979.

   In general such students are required to possess average or above average intelligence, but demonstrate a severe discrepancy between achievement and potential in one or more of the areas of oral or written language, reading or mathematics.

3. The authors would like to express their gratitude to Dr. Margaret Lowe of Denver, Colorado for her help in formulating the scoring procedures, and to Dr. Anne Nardi and Professor Richard Walls of West Virginia University, for their support and suggestion.

Table 1

Summary of Means for the Independent Variable Task

	Time/Trial	Trials	Strategy Score	Errors	Inclusive Errors (same position)	Inclusive Errors (different position)	Exclusive Errors
Task 1							
M	20.82	7.00	2.25	4.50	1.92	2.21	0.35
SD	10.44	2.61	1.11	5.37	2.62	2.60	1.70
Task 2							
M	17.51	5.61	2.07	1.82	0.42	1.25	0.14
SD	6.75	1.83	1.11	2.53	0.95	1.89	0.59
Task 3							
M	16.50	6.57	1.75	2.64	1.21	1.28	0.14
SD	7.04	2.42	0.88	2.65	1.42	1.82	0.44
Task 4							
M	16.03	6.67	1.46	3.00	1.71	0.96	0.32
SD	6.39	2.69	0.69	2.98	2.12	1.62	1.18